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Motivational Assessment Strategies in Business Analytics

Teaching Case

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Abstract

This teaching case describes an assessment component which was developed as part of a core undergraduate module in data analysis. The data analysis module is taken by all undergraduate business students at the School of Business in University College Dublin. We give a detailed description of the team project assessment component. This component was designed to address two key problems in business analytics education: how to engage business students in quantitative analysis and how to foster decision-making based on data analysis. We present promising results with analysis and some recommendations.

Keywords: Assessment strategies, encouraging quantitative skills development, business statistics

Introduction

Despite the predicted demand for students with skills in business analytics, our experience has shown that general business students at University College Dublin (UCD) are reluctant to select optional modules in business analytics. This may stem from a lack of understanding of what business analytics is. It may stem from a fear of technical nature of the subject.

Business analytics can be thought of as a complete business problem solving and decision making process underpinned by a set of analytical methodologies. The methodologies can be categorised as dealing with descriptive, predictive and prescriptive analytics. Sharda (2014) describe analytics as the process of developing recommendations for actions or actionable decisions based upon insights generated from historical data.

Despite the renewed focus that the emerging field of business analytics has brought to the quantitative education of business students, serious concerns remain about the ability of business schools to produce graduates with the skills needed to support industry adoption of advanced analytics, (Palocsay and Markham, 2014). Business school graduates are good at doing sound technical analyses, but they often have difficulty in applying that analysis to effective decision making, (AACSB, 2006). Business students often demonstrate a competent knowledge of analytical and statistical procedures but find explaining what the results mean challenging.

Students often perceive mathematics as hard and business students in particular perceive data analysis and statistics as boring and irrelevant to the real world, (McAlevey and Stent 1999; Gougeon 2004). There is a significant challenge to engage business students with quantitative topics and convince them of the relevance of these topics to their future careers in business. Cronin and Carroll (2015) note that business students recognise the importance of quantitative skills to business leaders but early stage business students often fail to make the link to their own personal learning and development.

In this study we describe the use of an assessment component which was developed as part of a core undergraduate module in data analysis. The module provides a foundation for business analytics focusing on descriptive and inferential statistics and is linked to a set of learning outcomes. The assessment

component aims to use the learning outcomes to demonstrate the practical nature of data analysis and that thought provoking insights can be created from data. Analysis of the performance of students on this assessment task in the 2015/2016 academic year is presented. Students engage well with this assessment component and demonstrate differing levels of attainment of the module learning outcomes. Some consistently weak areas of student understanding are identified in analysing the students' work.

The Data Analysis Module

Data Analysis for Decision Makers (DADM) is a core module for all (approx. 550 per annum) undergraduate business students at UCD. It is delivered in semester one of first year and is worth five credits on the European credit transfer system. The module was developed during the restructuring of undergraduate business degree programmes in 2011. Quantitative and analytical skills are central to the holistic education of business students. A founding in statistical data analysis is a requirement for Association to Advance Collegiate Schools of Business (AACSB) accreditation. The DADM module aims to foster sound decision-making practices based on data analysis and to offer students learning experiences in data analysis. It serves as a foundation for further modules in business analytics.

DADM was designed to ensure that students meet programme goals such as (a) being well-grounded in the theory and practice of quantitative aspects of business management, (b) being able to identify and comment critically on business. In particular students should "have the ability to gather and interpret relevant data to inform judgements that include reflection on relevant social, scientific or ethical issues". The DADM module was designed to enable students meet the following learning outcomes:

1. prepare spread-sheet models to store, manipulate and analyse quantitative data using common probability distributions and statistical functions;
2. calculate, analyse and present useful statistical measurements from large-scale data sets;
3. create and interpret inferential statistical statements about population parameters;
4. interpret the results of data analyses with a view to informing decision making.

A set of eLearning resources and a delivery mechanism that enable students to meet the learning outcomes were designed. The design was guided by the pedagogical principles and aligns with the GAISE recommendations on how to teach an introductory college statistics course, (ASA 2005). A student guide includes a description of the eLearning resources that accompany the module and gives a schedule of the face-to face activities and assessment components.

A variety of assessment methods can promote deep learning approaches among students. In DADM, grading criteria are used to quantify to what extent individual students have met the learning outcomes as evidenced by their performance on the assessment tasks. A summary of the DADM assessment tasks is shown in Table 1.

Table 1. DADM Assessment Components			
What	Week	Weight	Comment
Excel test	5	12%	Data Analysis using Excel
Online MCQ 1	7	7.5%	Covering theoretical and practical concepts
Online MCQ 2	9	7.5%	Covering theoretical and practical concepts
Team Project	11	13%	Open-ended project: Analyse data set and write a management report with recommendations
Written Exam	15	60%	End of Semester traditional written exam

Table 1. Data Analysis for Decision Makers Assessment Components

The assessment strategies are designed in line with the Dublin Descriptors, JQI (2004) to test if students can apply their knowledge and understanding of data analysis to solve problems within the field of business. In particular, the team project at the centre of this teaching case assesses whether students have the ability to gather and interpret relevant data to inform judgements and reflect on a specified business

topic. It offers students the opportunity to bring together all the ideas from the module and use their data analysis skills to reach conclusions about a contextual business problem.

Analytics Education

Palocsay and Markham (2014) note that reforms in management science education in the 1990s shifted the focus from teaching the detailed steps of algorithms toward spreadsheet-based quantitative analysis. This facilitated an increased emphasis on modeling, problem solving, and quantitative reasoning skills which are important skills in the decision making process.

The recommendations in ASA (2005) provide a set of guidelines for assessment and instruction in statistics education (GAISE). The guidelines offer a useful framework for business statistics courses. The recommendations suggest that lecturers should:

1. Emphasise statistical literacy and develop statistical thinking;
2. Use real data;
3. Stress conceptual understanding rather than mere knowledge of procedures;
4. Foster active learning in the classroom;
5. Use technology for developing conceptual understanding and analysing data;
6. Use assessments to improve and evaluate student learning.

Sharda (2013) note that many commercial software vendors have a keen interest in analytics education and offer academic partner programmes (APPs). The APPs may be useful in identifying suitable real world business data sets and appropriate case studies.

Igo and Coe (2016) describe the use of a case study that aligns with the AACSB recommendations to include learning experiences in data creation, data sharing, data analytics, data mining and data reporting.

Assignment Strategies in Analytics Education

The purpose of assessment is not only to provide certification of the level of achievement of learning outcomes, but also to promote learning by motivating students and informing them of their progress toward achieving the learning outcomes. This form of assessment is referred to as formative assessment. In addition, Bloxham and Boyd (2008) note the role of assessment in terms of assurance of learning. In all, assessment strategies that meet these objectives are challenging to design and implement, particularly in large class settings where students enter with differing levels of ability, motivation and learning styles.

Murphy (2010) notes that students tend to defer the learning process until prompted by a piece of assessment. McAlevey and Stent (1999) note that coursework in statistics-based courses may be particularly useful to students with humanities type backgrounds such as business students. The GAISE recommendations on active classroom learning and assessment are linked in Murphy (2010) and Woodard and McGowan (2012). Student buy-in in both cases is fostered by awarding a small proportion of the module grade to evidence of active class participation. Murphy (2010) notes that many students complete the bare minimum workload and asks if that attitudinal shift can be combated by using suitable assessment to enhance the learning of statistics. He reports some success with his experiment to assess assessment as an educational tool. He notes that students initially asked questions in class to gain the participation marks but by the end of semester they were freely asking questions without seeking credit.

Bloxham and Boyd (2008) note that each piece of assessment should be valid and should align with the module learning outcomes. The assessment task should be effective in promoting a deep approach to learning by students.

Case Study: DADM Team Project Assignment

The Team Project was designed as a capstone assessment component in the DADM module. It was informed by the pedagogic ideas and practices described above. A full description is included in the Appendix. Students are required to select an open source data set. A list of recommended sites and sources is provided. We recommend sources such as:

- the UCI Machine Learning Repository (<http://archive.ics.uci.edu/ml/o>);
- the United Nations Department of Economic and Social Affairs (<https://esa.un.org/unpd/wpp/>);
- the Irish State Examinations Commission (<https://www.examinations.ie>).

As an alternative, students may use a data set provided by faculty in the case they cannot identify a suitable source. Students have to apply suitable data analysis and summarise their findings and recommendation in a management report. Supports in report writing are available from the School Academic Writing Centre.

Students were given an option at the start of the semester on how teams should be formed. Students chose the option that faculty would record lecture and tutorial attendance and form teams of four based on attendance. A regular complaint in team work is the role of freeloaders. This approach to team formation partially addresses that concern. By using attendance to decide team membership we also hope to encourage attendance. Students were asked to indicate their contribution to the team project with the submission form. The team size of four was determined by faculty, in light of faculty resource availability, as being sufficiently small that each team member would be able to play a valid role.

Students submit their assessment report through Blackboard, the virtual learning management system used at UCD. Student submissions are processed through an anti-plagiarism package to ensure that the work has been produced by the student team. The assessments were graded by faculty using the rubric shown in Table 2. Each team received a grade, comments per team were made available and a high level summary of feedback was made available to the class.

The assessment addresses all but the fourth GAISE recommendation. The fourth recommendation is in relation to classroom activity. Students are given two weeks to complete the team project which is a specified learning activity and forms part of the workload associated with the DADM module. The team project is a capstone activity that maps to all the module learning outcomes. It provides students with learning experiences in identifying good/reliable data sources. If successfully completed, the team project shows that the application of data analysis (the technical part) can be implemented using spreadsheet tools. This increases students' confidence in their technical capabilities. Lastly, it provides a learning experience in showing the practical nature and potential benefits of business analytics.

Evidence of Efficacy

We obtained approval from the University Ethics Research Committee before conducting this case study. The data arise from standard educational tests and practices and are anonymised for research purposes. Information about the research project was given to students at the start of semester.

The team project is a valid assessment task as it aligns directly with all of the module learning outcomes. It is a complete capstone exercise that offers students the opportunity to work in teams to prepare spreadsheet models to calculate, analyse and present useful insights from data sets. The report deliverable of the project forces students to interpret the results of their analyses in a meaningful way.

Table 2 shows the grading rubric used for this assessment task. The criteria map to the deliverable components of the assessment. The rubric shows the performance expectations and the grade awarded for varying levels of mastery.

The students were divided into 132 teams with four members per team in most cases. In most cases (89%), students indicated that all team members had made an equal contribution to the project. In a small number of cases, the contribution weightings were unbalanced which required further investigation by the faculty team. Students have been advised that students who did not contribute to the team project might not receive the team grade.

The majority of teams (~90%) selected an open source data set ranging from areas as diverse as the sport, car performance, the economy, tourism and weather and climate. In our opinion, giving students the freedom to select the data sources allows students to select an area they find of mutual interest. Most teams stuck to those given in the recommended list with some teams commenting on the difficulty of finding a suitable source for specific topics. Many teams commented on the issues that arose in dealing with data formats and in dealing with missing data. This provided a very useful learning experience for early stage students.

The teams who selected the faculty provided data sets tended to do so close to the submission deadline. It suggests they either had difficulty identifying a suitable source or may have left it too late.

Performance Criteria	Exemplary (7 -10)	Acceptable (5 - 6)	Unacceptable (<=4)	Weight
Report Structure and format	The report is well formatted with a coherent structure. It includes separate sections such as: 1) Introduction (giving the context and data source); 2) Summaries (of descriptive and inferential statistical measures and results); 3) Conclusions and recommendations. 4) Tables of data and sample calculations are included in appendices. A bibliography citing sources is included.	The report includes some of the following sections: 1) Introduction (giving the context and data source); 2) Summaries (of descriptive and inferential statistical results); 3) Conclusions and recommendations. Tables of data and sample calculations appear in the report.	The report is disorganised and/or is missing some components. It contains spelling mistakes and does not cite sources.	0.10
Descriptive Statistics	The explanation of the statistical measures is meaningful and correct. An insightful interpretation of the results is included in the report.	Most of the explanations of the statistical measures are meaningful and correct. Some interpretation of the results is included in the report.	Explanations of the statistical measures are missing or incorrect. No interpretation of the results is included in the report.	0.25
Discrete Random Variable	The choice of variable and distribution is well justified. The distribution is demonstrated with a meaningful and correct example.	The choice of variable and distribution is not well justified. A distribution is demonstrated with a meaningful and correct example.	The choice of variable and distribution is incorrect. The distribution is not demonstrated correctly.	0.25
Continuous Random Variable	The application of inferential statistics is appropriate and explained well. The limitations and assumptions are clearly stated including reference to the sample size and data source.	The application of inferential statistics is appropriate and explained well.	The application of inferential statistics is inappropriate/in-correct.	0.25
Project Synthesis	The project demonstrates a depth of understanding of data analysis by applying appropriate analysis to relevant data which supports a set of recommendations for a business problem and clearly justifies the recommendation(s) to the decision maker.	The project demonstrates some understanding of data analysis. Analysis is applied to relevant data that partly supports the set of recommendations.	The project does not demonstrate adequate understanding of data analysis. Analysis is incorrectly applied and/or does not support the set of recommendations.	0.15

Table 2: Team Project Grading Rubric

Analysis of the student submissions shows that some student groups engage very deeply with the full module content in order to complete this assignment. Some teams submit comprehensive insightful analyses and commentary. At the other extreme, some projects are quite weak and show evidence of having been rushed and prepared at the last minute. This is consistent with previous work, (Carroll and White, 2016) that shows some early stage students are particularly assessment driven and adopt a just in time approach to assessment tasks. Students who failed the team project assessment component may have underestimated the work involved in completing the task. As a result, they may have missed out on the deep learning experience intended in this assessment task.

The high level feedback to the class indicates common areas of weakness. Common errors included confusing a sample with a population, confusing a discrete count variable with a continuous one and not recognising grouped data. The high level feedback given to all students included the following comments:

- Read the assignment specification carefully. To get a good mark you must address each of the three requirements in the report. Additional analysis is interesting but take care not to go off topic.
- Include units in descriptive statistics and analysis, 42 what? Euros, dollars, cm or hours etc? If median and mean are different, comment on this - this is the point of calculating such quantities.
- Fully label all graphs
- Reference all sources used in your report and include a bibliography at the end of your report. See the library site for further details
- Give a full citation for the data source by including its URL in your bibliography
- A proper introduction of data is important as it provides context to the report.
- Not all continuous distributions are Normal, there are many other patterns!
- There are many discrete random variable distributions. The binomial, Poisson and hypergeometric are just three types.
- Where full historic data for a population is given, the population parameters can be calculated and there is no need to use inferential statistics. Hence it is important to define your population - several teams used the CAO data which is population data not sample data and as such confidence intervals are meaningless unless framed correctly. (Note: the CAO is the Central Applications Office which is a central processing centre for applications to third level places based on Leaving Certificate results. The leaving Certificate is the end of secondary school state exam in Ireland.)
- Take care to use the correct language of data analysis. While we appreciate there are many terms and symbols, we didn't make them up! There are standard terms and symbols to describe your analysis.
- The data points in time series data tend to be correlated, a sample of such data is not an unbiased random sample so think carefully before using such data in inferential statistics.
- If we select a woman at random, she may be 170 cm tall, weight 54 kg and have €10 in her purse. We could calculate the average of these three numbers to be 78, but that would be completely meaningless!!!
- Take care when working with grouped data, the mean must be calculated as a weighted average across the groups and standard deviations may not be possible- for example arithmetic means and standard deviations of CAO/CSO/Census summary table data is inappropriate if not done properly
- A table of contents is useful in a report to frame the document and provide structure.
- Descriptive statistics are relatively meaningless without a graphical summary of the data such as a histogram.
- The Central Limit Theorem does not mean that every statistic will be normally distributed if you collect enough data, it's that the means of such samples will be normally distributed.
- Unless you explicitly state that "because my sample size n is etc, I am approximating my t statistic by a z statistic" then your confidence interval is erroneous. Many students used inappropriate z values where t should have been used.

Further analysis of the student performance is given next.

Analysis of Student Performance

The assessment task has been used over several academic years and is reliable in producing consistent grades from year to year. Student performance in the academic year 2015/2016 was broadly consistent with other years and across the continuous assessment components of the module.

Table 3 shows a summary of the grades for the assessment components. A visual summary of student performance is presented in Figure 1 below. Student scores across the two open book MCQ exams were similar to each other and are summarised in Figure 1.a. They show a median grade of 61 and an interquartile range of 21.

	Mean	Median	St. deviation	IQR
Project	57.51	61.66	15.80	13.33
MCQ	58.67	61.00	19.14	21.00
Excel Test	53.05	55.00	17.36	21.67
Exam	47.64	49.00	18.19	22.00

Table 3. Summary of Assessment Component Results

The median performance of students in the team projects was comparable, with a median grade of 61.6. However, the IQR is 13; the project grades are much less variable. This is shown in Figure 1.b. The substantially reduced variability in student performance in the team project is perhaps attributable to the pooling of student abilities across the teams of four. Team members with a more in-depth understanding of a given topic may compensate for a lack of knowledge in others; we encourage interaction and discussion between students in this manner in order to foster collaborative and peer-mentored learning where possible.

One interesting insight in the analysis of the project scores is that students typically scored lowest in the component associated with discrete random variables, with scores in this category on average 10% lower than the other project categories. MCQ questions on this topic are generally numerical in nature, due to the constrained format of such tests, so it appears that students are able to bypass their difficulties with understanding on the topic by referring to quantitative examples in the notes. These observations provide further confirmation for the experience of Stevens and Palocsay (2012), who identified student difficulties with the subject of DRV, and attempted to address it with a series of targeted examples.

Exam performance is shown in Figure 1.c. Student scores were markedly lower than the continuous assessment components, with a median grade of 49 and an inter quartile range of 22. The variability is similar to the MCQ setting, perhaps reflecting that access to course materials during the open book MCQ exam help students to “on average” score better, but with the variability across student performance maintained. Broadly speaking, the exam and team project are more similar in nature, with interpretation and understanding a vital component in scoring well. As perhaps would be expected, the lack of pooling of understanding between students results in the median student exam score dropping markedly. We are aiming to address this drop in performance through the provision of targeted online videos, which will provide more help to the students on the topics they identify as having difficulty with. Figure 1.d shows a box blot of the results for these three assessment components.

Conclusion

This study describes the use of a capstone assessment component in an introductory data analysis module. The team project described in this case study could be adapted or tailored to specific students groups. For example, students majoring in accounting may be directed to financial planning data and the deliverable might require that the report be written for the company’s chief financial officer rather than to a general management team.

The team project aids student learning in synthesising the theoretical concepts in data analysis and allows students to apply the theory to a practical business problem. It challenges students to really engage at a deep level. Students have an opportunity to apply, analyse, and evaluate their data analysis skills within this assessment task. The tasks map to Bloom’s learning objectives in the cognitive domain. This assignment is a useful tool in the teaching and learning toolkit and can increase student confidence in their analytical abilities.

While teams of four allowed most students to make an equal contribution to the project deliverables, in a small number of cases, teams reported an uneven distribution of the work effort. It is possible that early stage students need further supports in managing group work. In cases where sufficient faculty resources are available, an amended version of this project could be used as the basis for an assessment component per individual student.

Palocsay and Markham, (2014) note that there are four categories of business analysts based on roles and job responsibilities: champions, professionals, semiprofessional, and amateurs. The task of upskilling business students to transition from amateurs to champions remains.

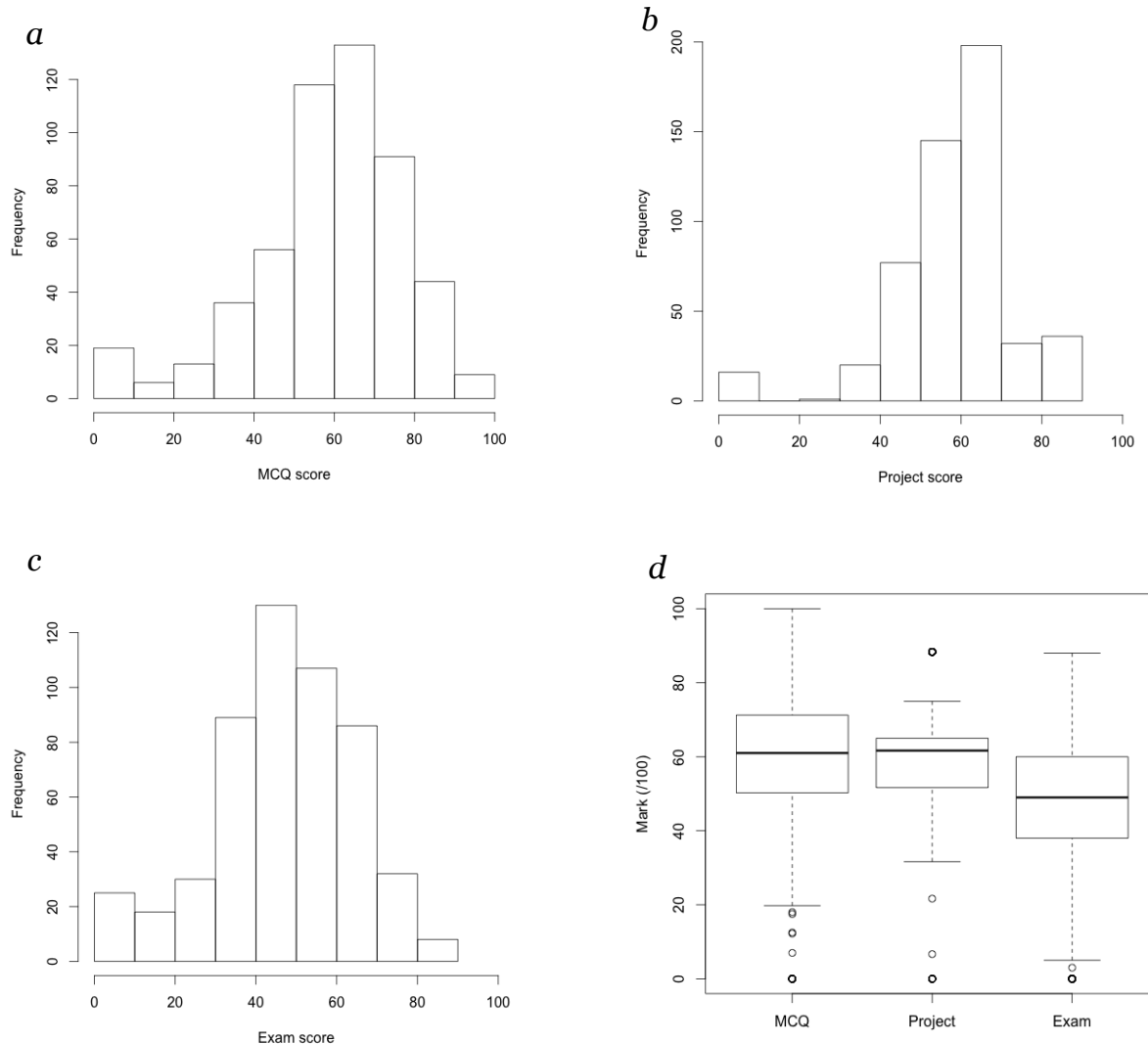


Figure 1. Analysis of results

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Appendix: DADM Team Project Description

The details below are given to students and discussed at lecture. Drop-in clinics are held where students can drop-in and discuss the assignment with faculty. Students may also use the University Maths Support Centre and School Academic Writing Centre.

Project Aims: Your team has been appointed to advise a manager on the applications of data analysis and statistics in business as an aid to decision making. She has asked you to write a management report to include:

1. A summary of your data using descriptive statistics and data presentation techniques (use Excel for this task);
2. An example of a discrete random variable relevant to your topic and its probability distribution;
3. Inferential Statistics on a relevant continuous random variable.

Source Data: Marks will be awarded for creativity in showing how data analysis can be applied in business. You may use select any topic of interest and any open source data appropriate to the application of business data analysis for that topic. As there are so many, we have identified a small subset for you to choose from on Blackboard. Your report should reflect on the data source and related data issues.

As an alternative, if you cannot identify a suitable Open Data source, you will find a fallback topic and sample data for your team on Blackboard. Using the fallback data demonstrates less creativity than using Open Data sources so will generally be awarded less marks.

Note: You may not conduct your own data gathering without ethical approval!

Team Code of conduct: Include a Statement of Authorship, signed by each participant of the group giving their weighted contribution. You may wish to include the Terms of Reference agreed by the group at the start of the project. Students who do not contribute to the team project, may not receive the team grade. Indicate the nominated team member on your Statement of Authorship. This person is responsible for uploading your work to Blackboard.

The Management Report: The aim of your report is to provide a meaningful interpretation of your data analysis to the business manager, demonstrating its use in decision making. Choose one discrete random variable and one continuous variable relevant to your topic. For example, a farmer may be interested in a discrete random variable counting the number of eggs successfully hatched from a batch and a continuous random variable measuring the weight of the chickens hatched.

To ensure a favourable response to your report, you need to explain to your manager any statistical terminology and techniques that you use in your report. Graphs may help the manager in understanding the concepts you are outlining. Rough work and calculations should not appear in the main body of the report but can be included in an appendix.

As this is a management report, format your report appropriately. All reports should be typed and neatly presented. Marks will be deducted for unprofessional aspects of your report such as misspellings, poor grammar, unreferenced sources or inappropriate graphs.

Suggested Management Report Content / Checklist for your report:

- 1) Introduction.
- 2) Summary and explanation of descriptive statistics. Calculate at least 2 measures of central tendency and at least 2 measures of variation for your Continuous Variable sample data. Explain the results and meaning of these measures in your report. Include a summary of the data in your report using a graph or table. Use Excel for this task.
- 3) Discrete random variable. Explain what your Discrete Random Variable is and what probability distribution can be used to describe it. Give some examples and interpretation of the usage of the probability distribution function and outline its business relevance.

4) Inferential Statistics. Calculate and interpret a confidence interval estimate of the Continuous Random Variable. Choose an appropriate confidence level for your interval. Or set up and conduct a hypothesis test relevant to the continuous random variable. Choose an appropriate level of significance for your test.

You should include:

- i) An explanation of your continuous random variable and sampling work
- ii) An explanation of what a Confidence Interval / Hypothesis Test is;
- iii) An insight into the construction of the interval/test;
- iv) An interpretation of your Confidence Interval/ Hypothesis Test results;

You may want to include some theoretical background to the Normal (and Sampling) Distribution. Topics could include:

- (1) What is the Normal Distribution?
- (2) Why is the Normal Distribution used in Sampling Distributions?
- (3) What is the basis for Inferential Statistics?

5) Summary and Conclusion.

6) Appendices can include sample tables of data, Excel work and/or calculations.

How to submit your project:

The team nominee uploads a soft copy of your report to the SafeAssign link in the Assessment folder on Blackboard. All members of the team should archive a copy of the report and Excel work.

Note: Submissions for this module are expected to exhibit academic integrity, whereby appropriate acknowledgement is given to the work of others through citation and references. Plagiarism is academic dishonesty and will attract the strongest penalties at university level. Less serious cases, where submitted work which is derivative from the work of others, may attract reduced marks or a requirement for resubmission.

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